UNIT THREE: COMMUNITY

Introduction

Few places on Earth preserve communities of ancient organisms where diversity can be observed. The National Park Service and the Bureau of Land Management preserve and protect some of these areas, which serve as outstanding windows into the past.

This unit extends the concepts learned in the adaptation unit by introducing the idea of ecological roles and interactions. As in the previous units, students will be encouraged to draw conclusions about the ancient world of fossils from their own modern world and experiences.

The kit contains examples of fossil herbivores, carnivores, and omnivores, and jaws and teeth of some modern animals the children are familiar with. After the teacher and class discuss how to tell an animal's way of life by looking at its fossil remains, especially its teeth, the students will classify the fossils according to ecological role. Then they will discuss how these animals fit into the ancient food web. Under the teacher's direction this will lead to a discussion of competition and interdependence.

A computer model provides another way of exploring interactions between members of a community. The simulation game used in this unit allows students to create their own scenarios involving modern or ancient ecosystems and experiment with the balance between predator and prey species.

Materials included in the kit

floppy disks for IBM and Apple computers with simulation software casts of fossil and modern herbivores, carnivores, and omnivores

Optional materials

colorful string, yarn, or flagging tape, slips of paper numbered from 1 to the number of students in the class, bowl for numbered paper slips

Objectives

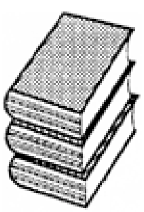
Upon completion of this unit students should understand the dual concepts of ecology (modern) and paleoecology (fossils) and should state in their discussions some similarities between modern and ancient ecosystems. They should be able to:

1) give examples of ancient ecosystems from the fossil record of a National Park System unit or area of public lands;

2) understand what food chains and food webs are and be able to cite a . particular example from a national park or monument or public lands;

3) discuss predators and prey species by giving both ancient and modern examples; and ..

4) understand diversity and how it is important for our own survival. They should be able to cite ways that biological diversity is beneficial to survival of ecosystems and for society.



VOCABULARY

Diversity The number of different kinds (species) of living things present in an ecosystem. Sometimes called biodiversity.
Ecology (ee-koPo-jee) The study of organisms and their interactions with their environment (study of ecosystems).
Ecosystem (ee-ko-sis-tem) A description of organisms and how they interact with their environment.
A progression from plants, which make their own food from sunlight, to herbi vores, which eat plants, to carnivores, which eat herbivores.
Food web How plants, predators, and prey interact. "Who eats whom." A way to describe linking of several food chains.
Organism Another name for a living thing: plant or animal.
Paleoecology *(pay-lee-o-ee-koEo-jee) Study* of ancient ecosystems as seen through the fossil record.
Predator An animal that hunts for its food.
Prey An animal that is the food source for a predator.

Overview

Community interdependence

A community is a group of populations of plants and animals living in the same area. It is possible to study isolated populations of plants or animals, or even individuals, but looking at the whole community gives scientists useful insights into how ecosystems function.

Each of the different organisms that live in a particular community is in some way dependent on all the others. This is called community interdependence. People often find out about how plants and animals are interdependent when they change one part of a community, only to discover that many other parts are also affected. For example, elimination of a prey species might cause a decline not only in the population of its major predator, but also in other animals used for prey.

Changes in the physical environment can cause important, and often unforeseen, changes in habitat. Damming of the North Platte River in Nebraska resulted in near elimination of spring floods, a "smoothing out" of flows. This allowed trees to colonize the sandbars in the river which had previously been swept clean of vegetation every spring by floods. Those sandbars were nesting habitat for wading birds. Loss of that habitat caused a drastic reduction in the population of those birds while it created a different habitat for other plants and animals.

Food webs

Food chains and food webs are ways of thinking about communities. All members of a community are linked together by a series of steps that involve eating and being eaten. This is called a food chain.

The bases of food chains are green plants, which make their food from sunshine by the process of photosynthesis. Next are the herbivores that eat the plants. Predators, who make their living by hunting and eating herbivores, are at the end of food chains. Food chains also include decomposers, such as bacteria and fungi, that recycle dead organic matter (from plants and animals) into the soil where its nutrients can be used by plants to start the cycle over again. A simple food chain might be:

grass - • grasshopper ~ mountain bluebird

In this example, the grass is eaten by the grasshopper who is eaten by the mountain bluebird. Simple food chains rarely exist by themselves. Many animals feed on several types of food. For example, foxes eat mice when they are abundant, rabbits when mice become scarce, berries when they are ripe, then grasshoppers in the fall. Because of complex eating habits like those of the fox, communities consist of interconnected food chains called food webs.

Each part of a food web depends on the other parts for energy to live. The source of energy for all life on Earth is sunlight. Plants get their energy from the sun, and when they are eaten, pass on stored energy to the herbivores that eat them. The herbivores then pass on some of their stored energy when they are eaten by predators. After being converted to other forms, the energy is effectively used up. It must therefore be continually supplied to the food web to keep it running. This shows just how important plants are in maintaining life.

Biodiversity

Biodiversity, or simply diversity, is a measure of the variety of different organisms that exist in a community. Species diversity is the number of different species living in a certain place. Ecosystem diversity refers to the number of different ecosystems in an area. An ecosystem includes a community of plants and animals in its physical environment. Ecosystem diversity happens where interactions between different communities and different parts of the physical environment occur in the same area.

When part of the environment is changed, as through loss of habitat, decrease in diversity can occur. For example, when a population of an organism runs out of places to live, it may die off. The more diversity in an area, the less any given change will affect the whole. Deep changes may cause the loss of an entire ecosystem.

If you think about how a food web functions, that is, energy flowing from plants through animals through decomposers and back to plants, the importance of diversity becomes clear. An ecosystem cannot function unless there are enough of all the parts to keep the system functioning.

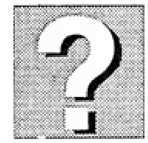
Biological diversity is also important in more direct ways for functioning of human society. We, like other living things, depend on the living and physical environment for sources for food, medicine, and building materials. New medicines, for example, are continually being discovered by scientists working with plants. and animals found in tropical rain forests. All of our food comes from living things originally found in nature. Both medicine and agriculture must keep going back to nature to improve their products, products without which we could not live. Our survival depends on having well-working ecosystems, and ecosystems in turn need all their parts to exist.

Paleoecology

Paleoecology is the study of ecosystems of the past through the fossil record. Paleoecologists use fossils and other information in the rocks to discover relationships between extinct animals and plants and their environment. Sometimes they make comparisons with modem ecosystems. It is useful to collect as many fossils as possible to get as good a picture as possible of the complete ancient ecosystem. For example, paleoecologists can learn about ancient diversity by counting the number of species they find as fossils from an area. But a few fossils will not be enough to really tell how many different species were present. Large samples give a better picture not only of diversity, but also of how much variation occurs in a given species.

Paleoecologists have been successful in reconstructing the ancient ecosystems of many places for different times in the past. An example of a well-known ancient ecosystem would be the Miocene (about 25 to 5 million years ago) of the Great Plains. The "good" fossil record of the Miocene shows numerous large mammals living on the plains. During the early Miocene there were more animals (like deer) that ate leafy vegetation than those that ate grass. But later in the Miocene grasses spread over the Great Plains and grazing mammals (like horses) began to dominate. Evidence from the fossil plants tells us that the climate became cooler and dryer during that time. Paleoecologists believe that the Great Plains region during the Miocene was very similar to the grasslands of Africa today. A good place to see and appreciate the diversity of Miocene fossils is at Agate Fossil Beds National Monument in western Nebraska.

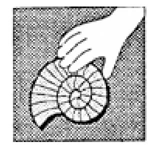
Pre-questions



1. **Where does your food come from?** Ask *this question at the beginning, and again at the end, of this unit. The bottom line is that our food comes from the sun: plants we eat (grains, fruits, and vegetables) get their energy to live from sunlight; animals we eat get their energy from plants.*

2. How can a paleontologist learn about the **community of plants and** animals living at times in the past? *Many times paleontologists find the plants and animals that lived in the past fossilized together in one place. They find clues in the rocks about the physical environments of the past.*

Pre-site activities



ACTIVITY 14 Computer Simulation: Predator-Prey Interactions

Ecologists sometimes use computers to run mathematical models that describe what happens to communities of plants and animals under certain controlled conditions. These models allow them to make predictions about the real world. Comparison with real-world observations then allows them to improve the model. Computer models are also useful in helping to understand ancient ecological situations. However, this particular. model is not typical of one that paleontologists could use, because continuous fossil records, accurate on the order of years, are extremely rare.

The model included in the teaching kit is similar to a model developed in the 1960s by ecologists. This version is very user-friendly and was designed especially for children. It uses simple mathematical relationships between the number of predators and prey in an area to predict how many of those animals will be in the same area at a later time. The mathematics is not visible to the user, but could be understood and probably modified by gifted children.

The system simulated could be a forest where foxes and rabbits live and interact, a meadow with ground squirrels and hawks, or a lake with herbivorous and carnivorous fish. Of course, the simulation is not limited to a modern scenario. It could just as easily be a Jurassic forest with herbivorous *Stegosaurus* and predaceous *Allosaurus,* or some other scene from the past. The program allows students to make their own decisions about the scenario and to follow changes in the modeled situation from year to year.

Running the simulation

The program is designed so that children who can read will be able to run it with little assistance. Versions for IBM and Apple II computers are included. Starting the program differs slightly depending on which computer is used. Follow the start-up instructions for your computer, next page.

[redacted]

DOS (IBM compatible): Insert either the 3 1/2 inch or 5 1/4 inch floppy disk in a disk drive (A or B) and close the door. Select that drive (type A: or B:) and then type "predator„ followed by the ENTER key.

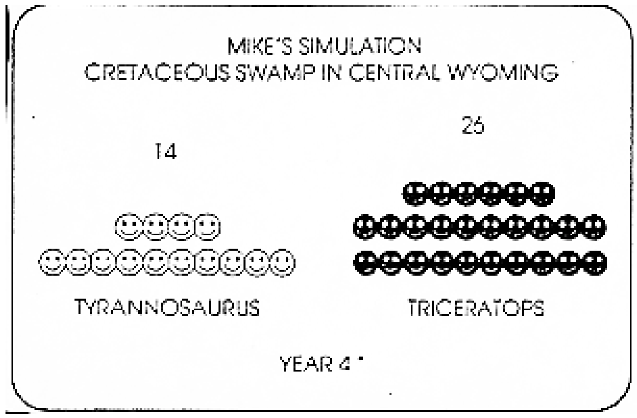
Apple: Insert the floppy disk, then either turn on the computer or type controlcommand-reset to boot up. The program will start automatically.

The program will guide you with a series of messages and prompts. A run session might look like the following example. In this example, the student's keyboard input is shown in italics.

> Hello! This is a model of predator-prey interactions. What is your name?
> *Mike*
>
> Hi, Mike. The computer is ready to do a simulation of predators and prey to show how they depend on each other for survival. A simulation is a sort.of game that might be true. But to make this game realistic, the computer needs your help. You need to use your imagination to make some decisions (computers don't have imaginations). Are you ready? *yes*
>
> First, we need a setting, a place for the story to take place. This could be a forest, a meadow, or a jungle 70 million years ago in the Cretaceous. Use your imagination! Describe your setting on one line. Then press the ENTER key. *Cretaceous swamp in central Wyoming*
>
> Thanks, Mike. Now we need a predator. What is the name of the predator in this story? *Tyrannosaurus rex*
>
> How many Tyrannosaurus vexes should we start out with? 4
>
> Good. Now, what is the prey? What does a Tyrannosaurus vex like to eat?
> *Triceratops*
>
> Now, how many Triceratopses should we begin with? 12
>
> Great! Now here's the story so far: The setting is a Cretaceous swamp in central Wyoming with 4 Tyrannosaurus vexes and 12 Triceratopses. When we're ready to go, the computer will fast-forward a year at a time and show you how many Triceratopses and Tyrannosaurus vexes are able to live in the Cretaceous swamp in central Wyoming. How many years do you want it to run? 20

Very good, Mike. Now we're ready. When you see the flashing star at the bottom of the screen, that means the computer is ready to go on with the next year. When you want to continue, press any key. Let's go! Press any key to continue.

The simulation then proceeds by showing graphically the number of individuals of the prey and predator that are present at the start of the simulation and at the end of each simulated year. A screen for a given year might look like this:



In this example, after four years, the predator is represented by 14 individuals and the prey by 26.

After the final year is done, the program will ask whether you want the computer to print your results. If a printer is connected to the computer, you may answer yes and the program will print out a summary of the whole simulation for the participant to keep.

Hints and recommendations

The purpose of a computer model like this one is to isolate critical parts of a known system and "see what happens" when some parts of the system are changed. It is designed for experimentation; there are no "right" or "wrong" answers. There are, however, some results that more than others will be similar to those encountered in the real world. Each student should therefore be allowed to try several different sets of inputs to compare the results.

We recommend that students start out with fairly small numbers of predators and prey and that the numbers of prey and predators are close. Then they can begin to experiment and ask questions such as the following: What happens when there is a large number of prey but very few predators? How about lots of predators and few prey? What are the differences when I use a large number of animals versus a small number? Why is there a cyclical (up and down) behavior of both predators and prey? Which one "leads" and which one "fags?" What are the conditions that encourage the most stable situation (smallest fluctuations in population)?

Perhaps the most important question the class should be asking is "Why does this system behave the way it does?" This is a simple model and the short answer to that question is that the number of predators the system can support is a function of how many prey are available. The number of prey in turn is dependent on the balance between their relatively high birth rate and predation pressure. Cyclical behavior results from the time lag between these pressures and their responses. Bear in mind that in the real world there is no environment limited to only one predator and its prey. Real ecosystems are complex and not isolated from each other. But then, they are much more difficult to study than this simple model.

ACTIVITY 15 A food web in the classroom

Message **A** food chain is a line from a plant through a herbivore to a carnivore. All food originates with green plants that make their food from sunlight. A food web is a complex of interconnected food chains.

Materials Colorful string, yarn, or flagging tape (cut 2-ft. lengths for each class member; have several longer pieces available); slips of paper numbered from 1 to the number of students in the class; bowl for numbered paper slips.

Participating in a simulated food web is one way for students to understand how complex the interrelationships in natural communities can be. This exercise starts out with simple food chains devised by the students with the help of the teacher. The food chains are then linked in meaningful ways chosen by the participants into a food web. This exercise should be done in a large open space such as a playground or gymnasium.

Procedure

1. **Think of some food chains.** Write them on the blackboard. Remember, all food starts with green plants-the only living things that can manufacture their food from sunlight. Next come herbivores, animals that eat plants. Then, carnivores, animals that eat herbivores. Most of the food chains will have three links, but some can have as few as two, or more than three. Since each link will be represented by a student, you need to think of enough food chains for the whole class. I f there are 30 students in the class, you **will** need about ten food chains. Here are some examples:

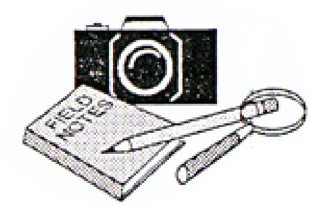
    willow---- moose -----wolf
    grass ---------grasshopper--bluebird
    wild oats ------deer mouse----fox
    chokecherry ---deer -------mountain lion
    pondweed------carp--- ---black bear
    sagebrush -----pronghorn ----coyote
    algae - ----snail ---- -bass ------------pelican
    plankton -------shrimp- -whale
    corn ----------pig--------- human
    alfalfa -------rabbit --------bobcat
    oak (acorn) -----squirrel -----eagle
    grass seeds ----prairie dog ---ferret

2. **Choose roles.** When there are food chains with enough links for all students, assign a link to each student. Do this by having them draw numbered slips of paper from a bowl. Then assign number 1 to the first link you wrote on the blackboard, and so on.

3. **Build food chains.** Have each child playing a plant to hold one end of a string (or tape). Give the other end of that string to the herbivore that eats that plant. Next, give another length of string to the child playing the herbivore (in the other hand) and the other end of that string to the carnivore in the food chain. Do this for each food chain.

4. Build a food web. Some of the students may be thoroughly involved in their roles and see that there are things in other food chains besides their own that they would like to eat. If so, link the eater with its food. Do this systematically by starting with the carnivores, then the herbivores. Don't leave out the plants-ask them if there is an animal in another food chain that might like to eat them. Ask the participants to choose a third, then a fourth, food item to link with. This could go on for even more steps, but you will probably run out of string and patience before then.

4. **Look at your food web.** Announce that the class has just constructed a food web. Scientists who study how plants and animals live together in their environment (ecologists) have a big job trying to understand all the interconnections (strings). Imagine how hard it is to understand the many interconnections in an ecosystem of the past from fossils.



Field Trip

Reconstructing ancient ecosystems

One of the most exciting parts of paleontology is reconstructing ancient ecosystems and animals and watching extinct plants and animals come to life in their natural world. Paleoecology can be a fascinating exercise for children, but doing a paleoecological exercise with real fossils found in the field is probably beyond the capability or desire of most teachers. This is where the assistance of local museums or parks will be most helpful.

Ask a representative of a park or museum if he or she can help you in your study of ancient ecosystems. Some institutions will be able to supply you with publications written for the general public on local paleoecology. Or maybe all that is available is a list of fossils collected in an area. This basic information can be a starting point for a class project. Prepare the class for the field trip by summarizing the information available. After the trip the students will be eager to talk about all that they have learned.

Try to learn as much as possible about the place and time you are studying. Have the students keep track of this information in a "paleoecology journal" kept just for this purpose. Information should include: where the area is (have the class make a map), when this ecosystem existed (include part of a geological time scale drawn by the students), what kinds of plants and animals lived there, what the vegetation was like (drawings), and who were the predators and prey. Also include, if available, drawings and writings describing how the animals and plants of this environment were fossilized.

More elaborate paleoecological reconstructions are possible if the time and energy of the teacher are sufficient. Possibilities for art projects abound. Have the class make clay sculptures of the plants and animals of your ecosystem in approximate relation to their actual abundance. The sculptures could then be displayed on a surface painted to took like a forest floor, grassland, or desert. Topography, such as mountains and coastlines, could also be sculpted and placed on the landscape. Many details of the paleoecology will not be known; let the students use their imaginations to supply them. Real paleoecologists are often faced with similar situations where they must use their best guess.

Post-questions

Think about the fossils of the place you visited on your field trip that lived together. Which ones are predators? Which are the prey? Are there some that you cannot tell? *Questions 1, 2 and 3 should be posed to your guide when you plan your field trip. Publications on well-researched fossil localities may also provide this type of information.*

Construct a food chain for the fossil animals and plants you are studying. *See no. 1. Remember that plants are at the bottom of food chains, herbivores come next, then carnivores.*

With the help of your classmates, construct a food web for the animals and plants that lived at the time of the fossils you studied on the field trip. *Remember that a food web consists of interconnected food chains.*

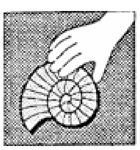
In what way does a predator species depend on its prey? *A predator depends on its prey for food to live.*

In what way does a prey species depend on predators? *A predator takes mostly weak, sick, or old members of prey species, and in doing so strengthens the bloodline of the prey by assuring that the strongest survive.*

Where does your food come from? (Hint: think of a food chain. Vegetables and grains you eat come directly from green plants that get their food from sunlight. *Meat you eat comes from animals that eat green plants.) The sun. See Pre-question 1.*

How healthy would an ecosystem be if many of its parts are missing? For example, what if there are very few predators? *An ecosystem with missing parts will be in trouble because all the parts depend on other parts. A shortage of predators may result in too many herbivores (prey). There might not be enough plants for them to survive the winter.*

Can you think of an example of an unhealthy ecosystem? *There are many possible examples: a polluted lake, a forest with all the trees cut down, a grassland that has been grazed too heavily.*



Post-site Activities

ACTIVITY 16
The fossilization game, part 2

Now that the class is thinking of *ancient organisms in terms of their ecological roles, repeat play of the "fossilization game" (page 11) with paleoecology in mind. Choose animals and plants to make a complete community. When you tally the results, take a look at how complete a representation of the community you have reconstructed. Is it complete or are there parts missing? How* different is *your view of the* reconstructed community *with some parts missing?* Do you think this reconstruction is *unrealistic? What happens when* you play *the game again?*

ACTIVITY 17 Writing about ancient communities

Message You can use your imagination and what you've learned about communities and fossils to write an interesting story about communities of the past.

Materials Pencils; writing paper or learning logs.

This activity is similar to activity 12: a picture story on adaptation. Students in this activity are limited to being animals (not plants or animals as in activity 12) because they will write about their favorite foods. The story can be a "formula" based on the descriptions below, or can be free-form.

Procedure

1. Choose the role of an ancient animal. This could be any animal that the students encountered in their visit to a museum or park, or in their reading.

2. **Describe your environment.** This requires some knowledge of the ancient ecosystems as reconstructed by a paleontologist or interpreted by a park ranger or guide. Let the students be as creative as they wish. Some students may include imagined details of the environment that were not previously discussed. This is OK as long as they can justify their reasons.

3. **Describe your community.** In this part, the students should give examples of the other plants and animals that live with them. This information will be available from park rangers or in publications.

4. Describe a food chain. Begin by listing your favorite food. Are you a carnivore or a herbivore? If you are a herbivore, what animal tries to hunt you? How have you kept from getting eaten so far?

5. Describe a food web. Pretend your favorite food disappears. If your favorite food is not available what do you eat? How many different kinds of food fit into your diet? What other kinds of food do the other animals in your food chain (No. 4, above) like to eat?

5. Imagine a big change. What would you do if all your food disappeared because of that change? What could you do? Would you move away? How would the other members of your food web survive? This is an example of an ecological disaster because food chains and food webs would be forced to come apart.

Ancient communities preserved intact

Discovering how extinct plants and animals lived together in their environment is the task of paleoecologists. But there are not many places where it is easy to see all the different parts of ancient ecosystems in one place. Fortunately, one of the best places to see the workings of a complex ancient ecosystem, and even some cases of interaction, is a national monument surrounded by public lands: Fossil Butte National Monument in southwestern Wyoming.

The ancient ecosystem at Fossil Butte centered on three large lakes that existed in the area about 50 million years ago. In those lakes were deposited muds that hardened into the Green River Formation, one of the largest known lake deposits in the world. At certain times during the lakes' history, conditions were favorable for the preservation of fossils. The fossil record of the Green River Formation is an amazing resource for paleontology. Organisms from single-celled bacteria and spores to 16-foot crocodiles are preserved. The fossil flora (plants) is also well represented. Palms and other tropical and subtropical plants tell us that the climate was much warmer than today.

Fish are the most abundant fossils found in the Green River Formation near Fossil Butte; many fish specimens from this area can be seen in museums around the world. The deposit is rich in other vertebrates as well. Frogs, salamanders, lizards, snakes, alligators, birds (including tracks and feathers), bats, and some larger mammals are found among the vertebrate fossils. Invertebrates include clams, snails, prawns, crayfish, and insects.

Most importantly, cases of interaction between different parts of the ancient environment can be seen. A leaf gnawed by an insect, or a fish with another species of fish in its stomach, are examples of direct evidence of ancient food chains. Trackways of birds, lizards, and worms provide striking examples of interactions of animals with their physical environment.

The Fossil Butte visitor center contains a modern museum displaying many plant, vertebrate, and invertebrate fossils collected from the region. Visualizing living things that have been buried in mud, now turned to layer upon layer of rock, will become easier for many children after visiting the Fossil Butte visitor center and looking at nearby exposures of rock.

Fossil Butte National Monument is located 11 miles west of Kemmerer, Wyoming.

A Guide to Fossils, Helmut Mayr, Princeton University Press, 1989. (ISBN 0-691-08789-X) A small picture book packed with information about fossil plants, vertebrates, and invertebrates. A representative selection of the more common fossils, illustrated by exceptionally well-preserved material. The pictures, along with detailed technical descriptions, may be useful in helping amateurs identify fossils.

The Search for the Past, L.B. Halstead, Doubleday & Co., 1982. (ISBN 0-385-18212-0) An encyclopedic, interestingly written and illustrated introduction to geology, sedimentary rocks, and paleontology. Discusses the meaning of fossils, how fossilization occurs, trace fossils, history (including famous hoaxes), and evolution. Enhanced with examples from the around the world. Presents explanations of food webs and other concepts from ecology.

Mighty Mammals of the Past: A Detective Story of Earth's Animal Ancestors, John Stidworthy, Silver Burdette, 1986. (ISBN 0-382-09321-6) A lively account of the rise of mammals. Gives a good introduction to the diversity and ways of life of mammals during the last 60 million years.

Books for children

Evolution, Joanna Cole, Harper Collins Publishers, 1987. (I S B N 0-06-445086-4) Suitable for children in the early elementary grades, this book provides an introduction to some of the ideas of evolution.

Dinosaurs, a Journey Through Time, Dennis Schatz, Pacific Science Center, 1987. (ISBN 0-935-05101-5) Information on paleontology and ideas about dinosaur life. This book is a good source for classroom or individual activities. Contains cut-outs to make stand-up dinosaurs and game cards.

The Usborne Young Scientist: Evolution, Barbara Cork and Lynn Bresler, EDC Publishing Co., 1986. (ISBN 0-86020-867-2) This book is suited for the upper elementary grades. It contains background material and activities to help the reader understand concepts of evolution.

Video

Dinosaurs, Puzzles From the Past, No. 51046, National Geographic Society, Educational Video Presentations, Washington DC 20036. Excellent 20-minute video about the geological time line.